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(54) Abstract Title
Air conditioner

(57) An air conditioner comprises an outdoor unit (27) having an outdoor heat exchanger, a compressor and a plurality of capillary tubes (24a,24b,24c) respectively having different resistances and having ends connected to the outdoor heat exchanger and other ends connected to connecting valves (26a,26b,26c), respectively; an indoor unit (32) having an indoor heat exchanger; and a first pipe (33a) and a second pipe (33b), interconnecting the outdoor unit (27) and the indoor unit (32), respectively. The second pipe (33b) has one end connected to the indoor heat exchanger and the other end connected selectively to the connecting valve (26a,26b,26c) connected to one of the capillary tubes (24a,24b,24c), having a resistance matching the length of the second pipe (33b).

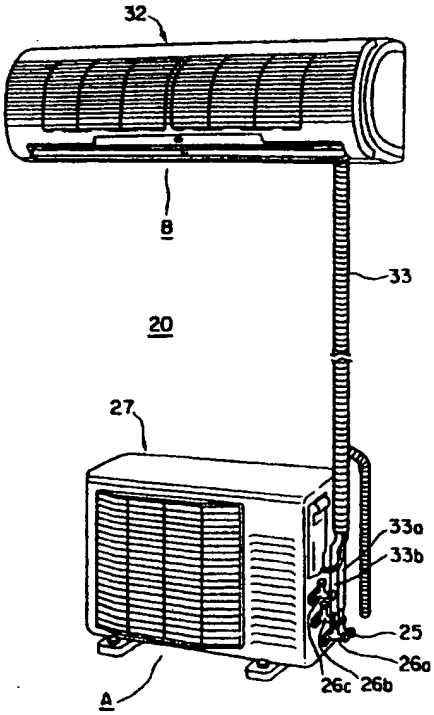

FIG. 1

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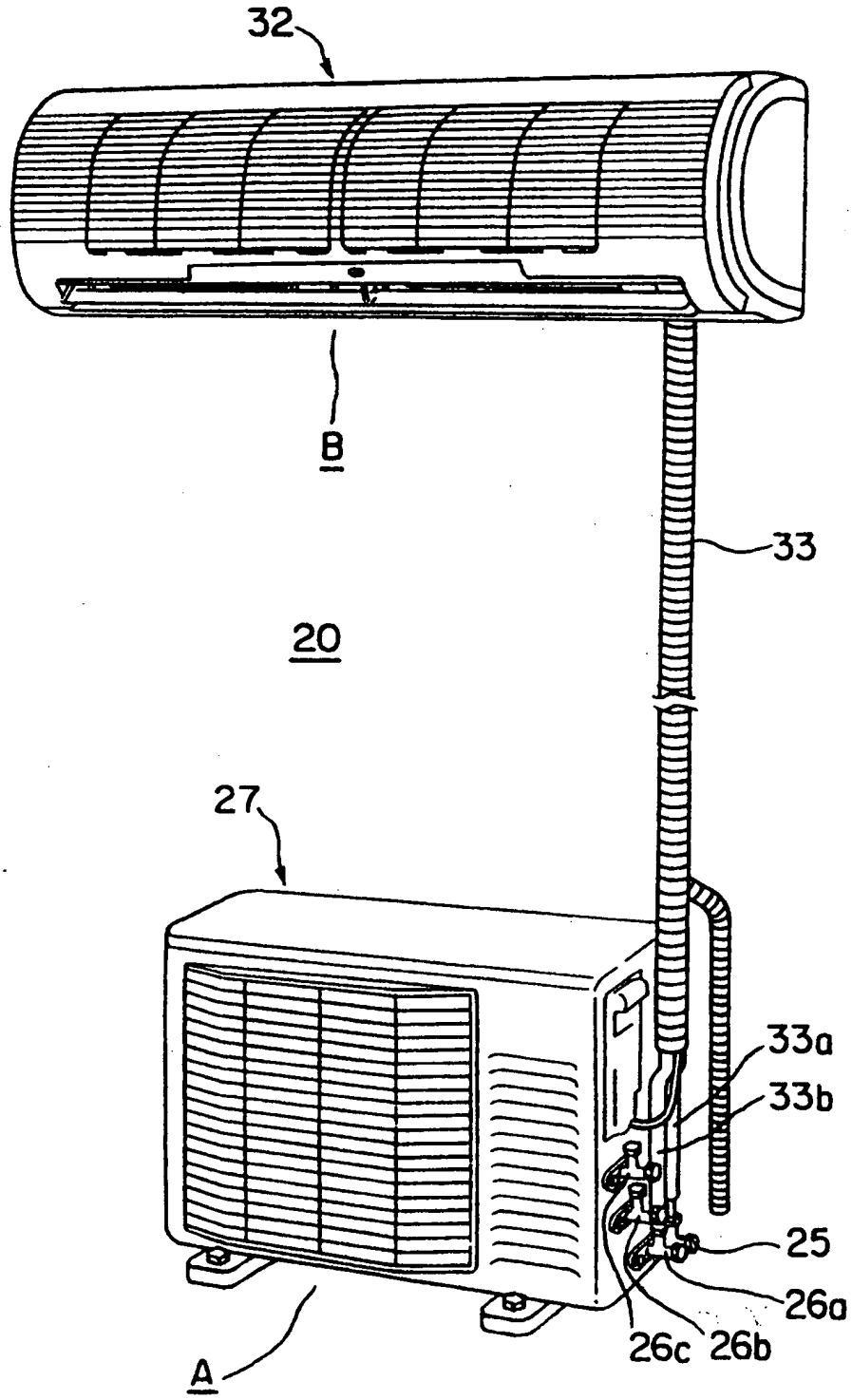


FIG. 1

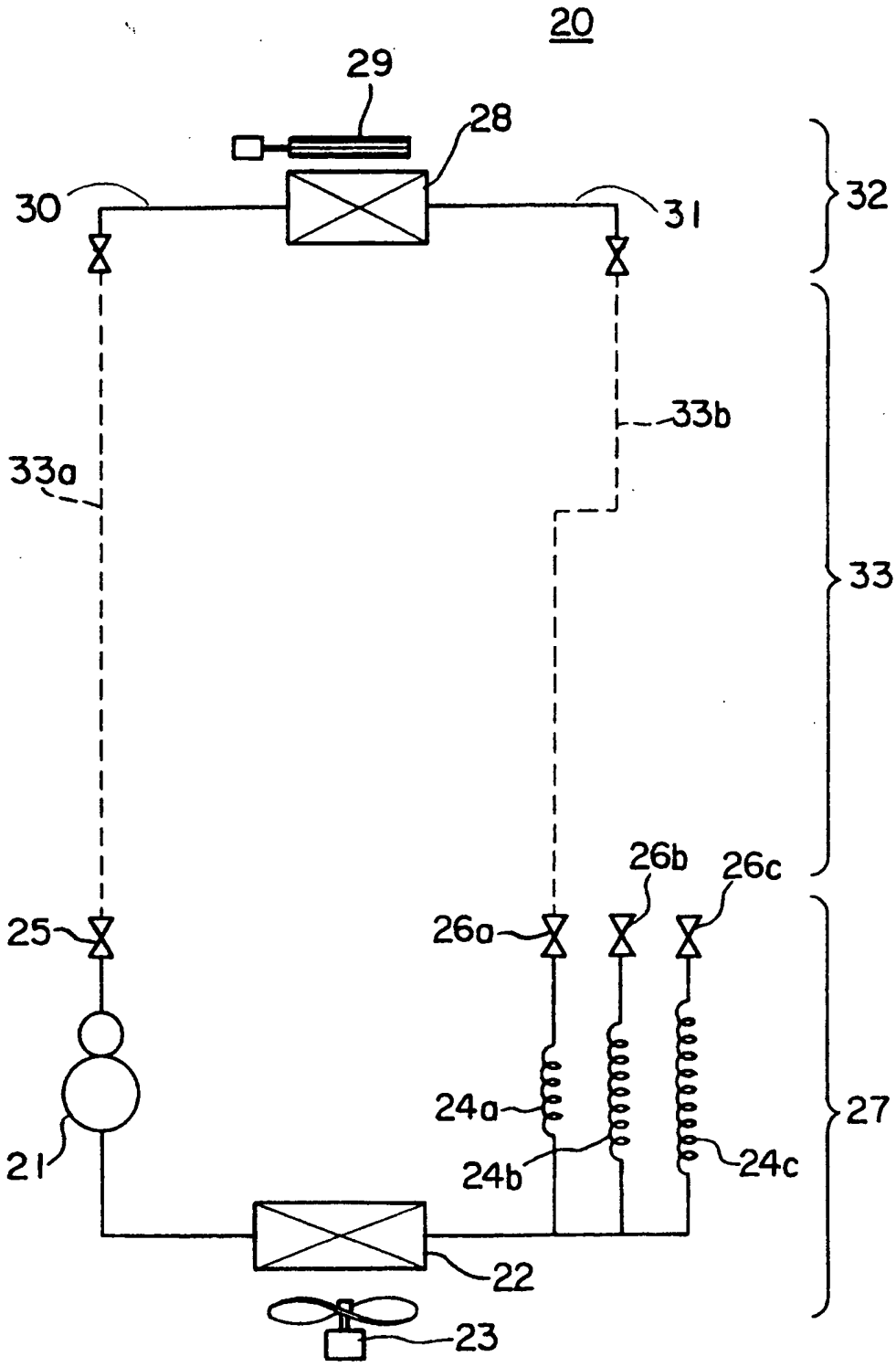


FIG. 2

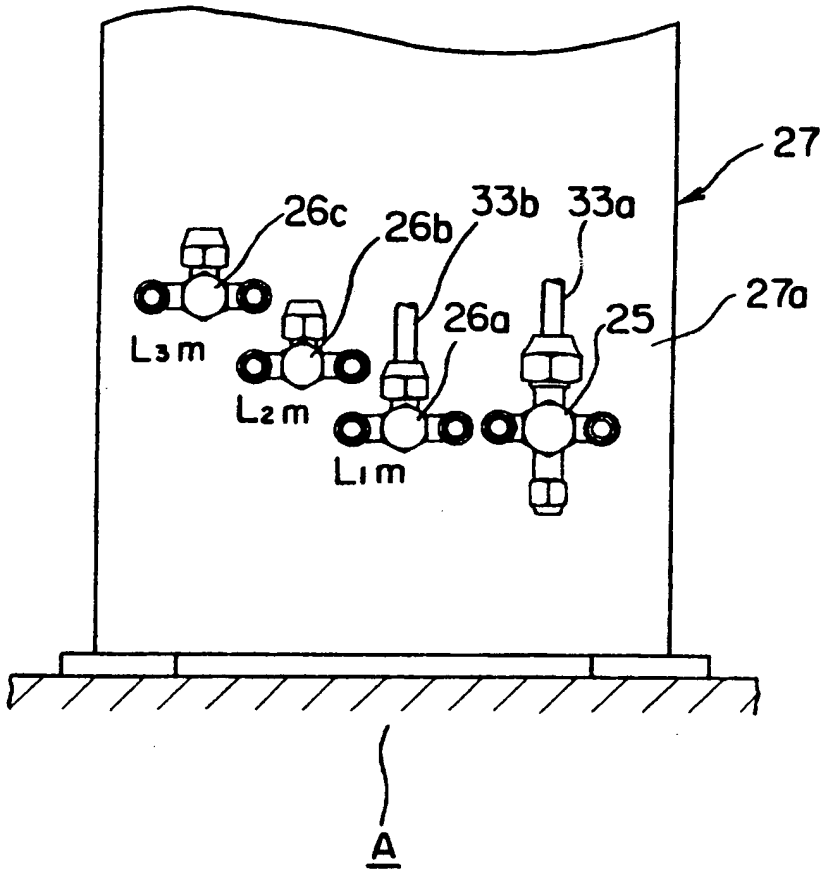
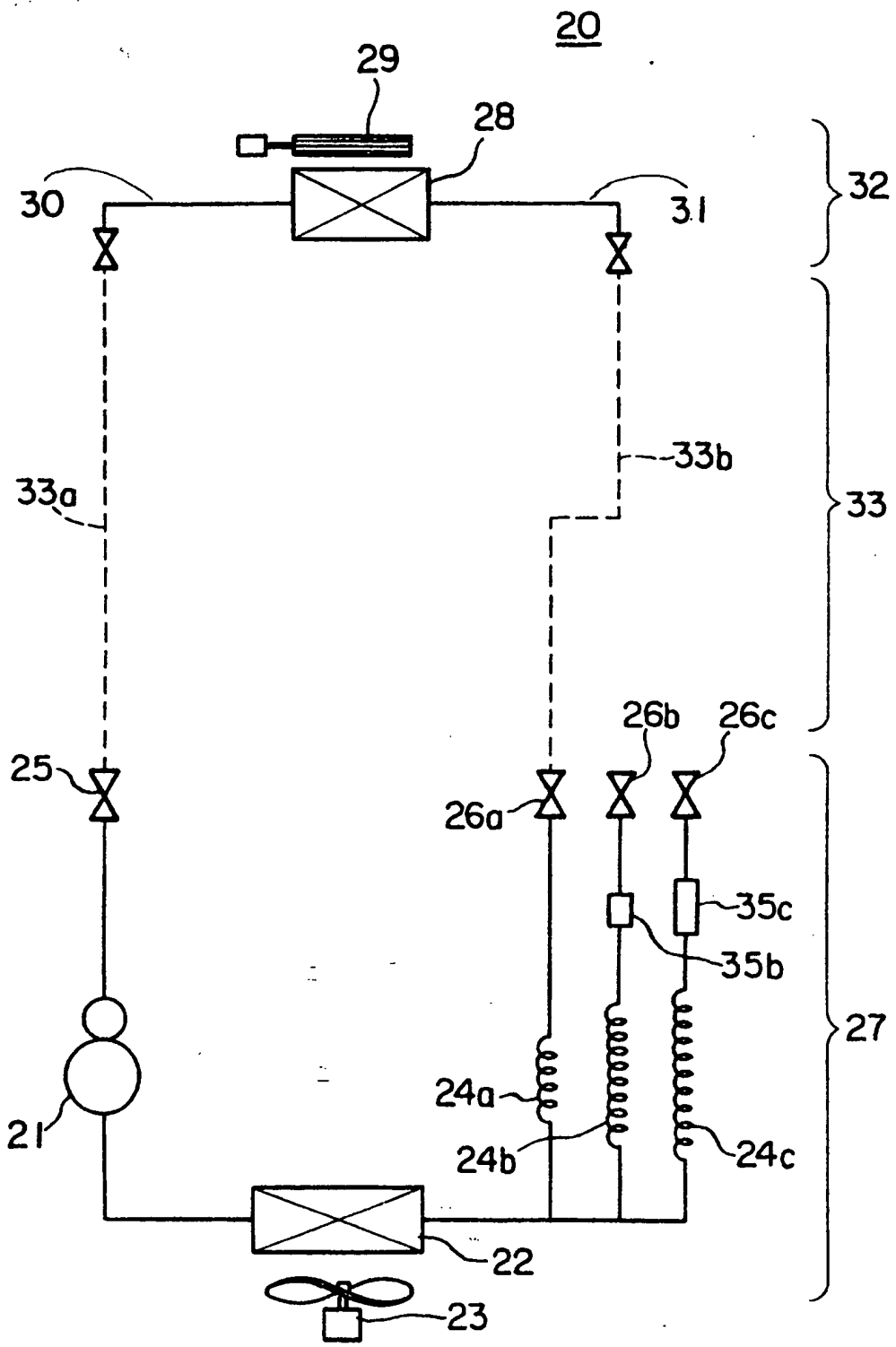


FIG.3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33b
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26c
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35c
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FIG. 4

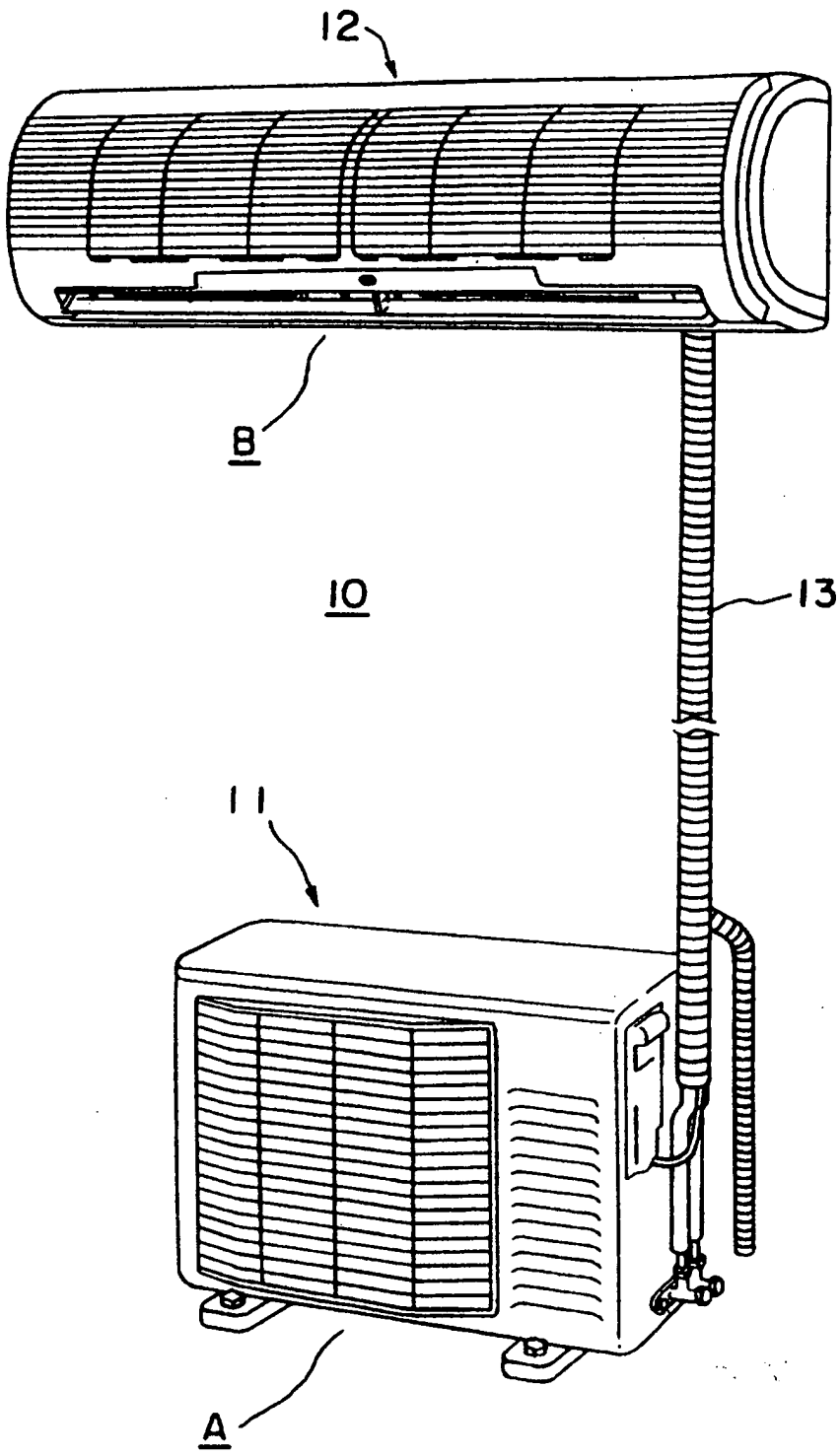

FIG.5

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AIR CONDITIONER

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an air conditioner comprising an outdoor unit, an indoor unit and piping interconnecting the outdoor unit and the indoor unit.

Description of the Related Art

Referring to Fig. 5, a generally known air conditioner 10 has an outdoor unit 11 provided with an outdoor heat exchanger, a compressor and an outdoor fan, an indoor unit 12 provided with an indoor heat exchanger and an indoor fan, and piping 13. The outdoor unit 11 of the air conditioner 10 is installed on a base A. The indoor unit 12 is mounted on an inner wall B and is connected through the piping 13 to the outdoor unit 11.

Recently housing designs have become widely varied. Generally, the necessary length of the piping 13 is in the range of 3 to 5 m for one-storied houses, and 10 to 20 m for two-storied houses, in some cases, can be more than 20 m for houses with three or more stories. Therefore the length of the piping 13 is in the range of about 3 m to 20 m or above depending on the position of the indoor unit 12 relative to the position of the outdoor unit 11. If the length of the piping 13 is different from a standard length, the air conditioner 10 is unable to operate in a refrigeration cycle of predetermined characteristics. The quantity of the refrigerant contained in the refrigeration system of the air conditioner is adjusted according to the length of the piping when the air conditioner is installed or the quantity of the refrigerant circulating through the refrigeration system is regulated by an electrically or electronically controlled expansion valve while the air conditioner is in operation.

The quantity of the refrigerant to be contained in the refrigeration system is not necessarily correctly adjusted when the installer installs the air conditioner. If the quantity of the refrigerant is not correctly adjusted, the air conditioner will be unable to maintain the refrigeration cycle of the predetermined

characteristics. Furthermore, the installer always needs to carry around a cylinder containing the refrigerant, which is troublesome.

Control of the flow of the refrigerant by an electrically or electronically controlled expansion valve is an ideal means for properly controlling the refrigeration cycle. Control of the flow of the refrigerant, however, needs detectors and devices including a computer and a controller for carrying out a complicated control procedure. The employment of detectors, the computer, the controller and the like will increase the cost of the air conditioner beyond an acceptable cost of domestic air conditioners.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an air conditioner comprising an outdoor unit, an indoor unit and piping for interconnecting the outdoor unit and the indoor unit, and capable of properly carrying out a refrigeration cycle with a fixed quantity of refrigerant regardless of the length of the piping.

According to a first aspect of the present invention, an air conditioner comprises an outdoor unit having at least an outdoor heat exchanger, and a plurality of capillary tubes connected in parallel to the outdoor heat exchanger and respectively having different resistances; an indoor unit having at least an indoor heat exchanger; and first and second pipes.

In this air conditioner, the second pipe is connected selectively to one of the capillary tubes of the outdoor unit, having a resistance matching the length of the second pipe, interconnecting the outdoor unit and the indoor unit, respectively. Since the difference of the length of the first and second pipes from a standard length can be compensated by the resistance of the capillary tube, the air conditioner is able to carry out a refrigeration cycle properly without requiring the adjustment of the quantity of a refrigerant contained in a refrigeration system thereof.

Preferably, one end of each of the plurality of capillary tubes is connected to the outdoor heat exchanger, and the other

end of the same is connected to a connecting valve to which the second pipe is to be connected. The connecting valve facilitates work for connecting the second pipe to the selected capillary tube.

A refrigeration system is formed by connecting the second pipe to a connecting valve connected to the compressor of the outdoor unit 27 and connecting the second pipe to one of the plurality of capillary tubes, the quantity of a refrigerant contained in the refrigeration system is determined on the basis of a combination of the greatest length of the first and second pipes and the resistance of the capillary tube having the lowest resistance, and reservoir tanks are connected in series to the capillary tubes except for the capillary tube having the lowest resistance, respectively.

The reservoir tanks prevents the deterioration of the performance of the refrigeration system when the capillary tube having a resistance not matching the length of the pipe is used.

Preferably, the reservoir tanks having greater capacity are connected to the capillary tubes having higher resistances.

An excessive part of the refrigerant can be stored in the reservoir tank.

Preferably, the reservoir tanks contain a desiccant to remove moisture from the refrigerant.

Preferably, the connecting valves are mounted on a side wall of a casing of the outdoor unit to facilitate work for connecting the pipe to one of the connecting valves.

Preferably, the connecting valves are arranged at horizontal intervals to facilitate work for connecting the two pipes to the connecting valves.

Preferably, the connecting valves are mounted on the side wall of the casing of the outdoor unit at different heights, respectively, to facilitate work for connecting the pipes of different lengths to the connecting valves.

Preferably, marks indicating the respective lengths of pipes to be connected to the connecting valves, respectively, are provided on the side wall of the casing of the outdoor unit on which the connecting valves are mounted, at positions near the

corresponding connecting valves to facilitate work for selecting the appropriate connecting valve.

The above and other objects, features and advantages of the present invention will become more apparent from the following description taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of an air conditioner in a first embodiment according to the present invention;

Fig. 2 is a diagrammatic view of a refrigeration system included in the air conditioner of Fig. 1;

Fig. 3 is a fragmentary side view of an outdoor unit included in the air conditioner of Fig. 1;

Fig. 4 is a diagrammatic view of a refrigeration system included in an air conditioner in a second embodiment according to the present invention; and

Fig. 5 is a perspective view of a conventional air conditioner.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An air conditioner in a first embodiment according to the present invention will be described with reference to Figs. 1, 2 and 3. As is obvious from Fig. 1, an air conditioner 20 specially designed for cooling is basically similar to the conventional air conditioner 10 shown in Fig. 5. Referring to Fig. 2, the air conditioner 20 comprises an outdoor unit 27 having an outdoor heat exchanger 22, a compressor 21, an outdoor fan 23, capillary tubes 24a, 24b and 24c respectively having a low resistance, a medium resistance and a high resistance, and connecting valves 25, 26a, 26b and 26c; an indoor unit 32 having an indoor heat exchanger 28, an indoor fan 29 and pipes 30 and 31 connected to the indoor heat exchanger 28; and piping 33 interconnecting the outdoor unit 27 and the indoor unit 32.

The capillary tubes 24a, 24b and 24c have ends connected to the outdoor heat exchanger 22, and other ends connected to the connecting valves 26a, 26b and 26c, respectively. The

piping 33 comprises a first pipe 33a and a second pipe 33b. The first pipe 33a has one end connected to a connecting valve 25 connected to the compressor 21 of the outdoor unit 27 and the other end connected to the pipe 30. The second pipe 33b has one end to be connected to one of the connecting valves 26a, 26b and 26c of the outdoor unit 27 and the other end connected to the pipe 31 of the indoor unit 32. The respective lengths of the first pipe 33a and the second pipe 33b vary in the range of 3 m to 20 m or above depending on the distance between the outdoor unit 27 and the indoor unit 32.

The capillary tube 24a having the low resistance is suitable for use in combination with the second pipe 33b of a length exceeding 20 m, the capillary tube 24b having the medium resistance is suitable for use in combination with the second pipe 33b of a length in the range of about 10 to about 20 m, and the capillary tube 24c having the high resistance is suitable for use in combination with the second pipe 33b of a length in the range of about 3 to about 10 m. The connecting valves 25, 26a, 26b and 26c are substantially the same in construction. When any pipe is not connected to the connecting valves 25, 26a, 26b and 26c, the connecting valves 25, 26a, 26b and 26c are closed. The connecting valve 25 is opened after the first pipe 33a is connected thereto, and the connecting valve 26a, 26b or 26c is opened after the second pipe 33b is connected thereto to enable the refrigerant to circulate through the refrigeration system.

As shown in Fig. 3, the connecting valves 25, 26a, 26b and 26c are mounted on a side wall 27a of a casing included in the outdoor unit 27 at horizontal intervals. The connecting valves 25 and 26a are at substantially the same height from a base A for the outdoor unit 27, the connecting valve 26b is at a position higher than those of the connecting valves 25 and 26a, and the connecting valve 26c is at a position higher than that of the connecting valve 26b. Such an arrangement of the connecting valves 25, 26a, 26b and 26c facilitates work for connecting the two pipes 33a and 33b of different lengths to the connecting valve 25 and the selected one of the connecting valves 26a, 26b and 26c, respectively. Marks "L1m", "L2m" and "L3m" indicating

the length of the pipes 33a and 33b are inscribed on the side wall 27a of the outdoor unit 27 at positions below the connecting valves 26a, 26b and 26c. The marks "L1m", "L2m" and "L3m" specify lengths exceeding 20 m, lengths in the range of 10 to 20 m, and lengths in the range of 3 to 10 m, respectively. The marks "L1m", "L2m" and "L3m" facilitate the selection of one of the connecting valves 26a, 26b and 26c to which the second pipe 33b is to be connected.

The pipes 30 and 31 are extended in piping grooves, not shown, formed in the indoor unit 32. The pipes 33a and 33b are connected to the pipes 30 and 31, respectively.

The air conditioner 20 is designed and manufactured on an assumption that the longest usable pipes 33a and 33b are to be used, and the outdoor unit 27 is charged with a quantity of refrigerant appropriate to the achievement of an optimum refrigeration cycle when the air conditioner 20 uses the longest usable pipes 33a and 33b. The outdoor unit 27, the indoor unit 32 and the pipes 33a and 33b of the piping 33 are transported to a site for installation.

When installing the air conditioner 20 at the site, the outdoor unit is set on the base A, and the indoor unit 32 is mounted on an inner wall B as shown in Fig. 1. Next, as shown in Fig. 2, one end of the first pipe 33a of a sufficient length is connected to the pipe 30 and the first pipe 33a is extended through the wall of a house to a position near the connecting valve 25, and one end of the second pipe 33b of a sufficient length is connected to the pipe 31 and the second pipe 33b is extended through the wall of the house to a position near the connecting valves 26a, 26b and 26c. The other end of the first pipe 33a is connected to the connecting valve 25, and the other end of the second pipe 33b is connected to the connecting valve 26a, 26b or 26c connected to the capillary tube 24a, 24b or 24c having the resistance matching the length of the second pipe 33b.

If the pipes 33a and 33b are the longest usable pipes of a length exceeding 20 m, the second pipe 33b is connected to the connecting valve 26a specified by the mark "L1m" (20 m or above) and connected to the capillary tube 24a having the resistance

matching a length exceeding 20 m. The connecting valve 26b is selected for the second pipe 33b of a medium length and the connecting valve 26c is selected for the second pipe 33b of a short length.

Thus, the pipes 33a and 33b can be connected easily to the outdoor unit 27 regardless of their length. The cooling performance of the air conditioner 20 is scarcely deteriorated and the air conditioner is able to operate normally even if the air conditioner 20 is not replenished with the refrigerant regardless of the length of the pipes 33a and 33b because the capillary tube 24a, 24b or 24c having the resistance matching the length of the second pipe 33b is used. Since the capillary tubes 24a, 24b and 24c of different resistances are quite inexpensive as compared with the electrically or electronically controlled expansion valve and hence do not increase the manufacturing cost of the air conditioner 20.

Fig. 4 illustrates the refrigeration system of an air conditioner 20 in a second embodiment according to the present invention. The second embodiment is developed by incorporating improvements into the first embodiment and is substantially the same in configuration as the first embodiment. Therefore, parts of the second embodiment like or corresponding to those of the first embodiment are designated by the same reference characters and the description thereof will be omitted.

In the first embodiment, one of the capillary tubes 24a, 24b and 24c having an appropriate resistance is selectively used according to the length of the pipes 33a and 33b. However, it is difficult to enable the air conditioner 20 to achieve the refrigeration cycle properly even if the resistances of the capillary tubes 24b and 24c are adjusted accurately relative to the reference resistance of the capillary tube 24a.

In the second embodiment, the quantity of the refrigerant contained in the refrigeration system is determined on the basis of a configuration of the refrigeration system using the longest pipes 33a and 33b of a length exceeding 20 m in combination with the capillary tube 24a having the low resistance. If the room air conditioner 20 is used in combination with the pipes

33a and 33b of the medium or the short length, and the capillary tube 24b having the medium resistance or the capillary tube 24c having the large resistance, the quantity of the refrigerant may be excessively large. Therefore, a reservoir tank 35b of a medium capacity of, for example, 30 cm^3 and a reservoir tank 35c of a large capacity of, for example, 100 cm^3 are connected in series to the capillary tubes 24b and 24c, respectively, to reserve the surplus refrigerant. When the pipe 33b is used in combination with the capillary tube 24b (24c) the surplus refrigerant is stored in the reservoir tank 35b (35c). Thus, the air conditioner 20 is able to exercise utmost cooling performance regardless of the length of the pipes 33a and 33b.

If the reservoir tanks 35b and 35c contain a desiccant, such as molecular sieve, moisture contained in the refrigerant can be removed, so that the refrigerant is able to maintain its normal performance for a long period of use.

Although the present invention has been described as applied to a cooling air conditioner, naturally, the present invention is applicable also to heating/cooling air conditioner. The air conditioner of the present invention may be provided with two capillary tubes or four or more capillary tubes.

Although the invention has been described in its preferred embodiments with a certain degree of particularity, obviously many changes and variations are possible therein. It therefore should be understood that other versions without departing from the scope and spirit of that specifically described herein.

WHAT IS CLAIMED IS:

1. An air conditioner comprising:

an outdoor unit having at least an outdoor heat exchanger, and a plurality of capillary tubes connected parallel to the outdoor heat exchanger and respectively having different resistances;

an indoor unit having at least an indoor heat exchanger; and

a first pipe and a second pipe, interconnecting the outdoor unit and the indoor unit, respectively;

wherein the second pipe is connected selectively to one of the capillary tubes of the outdoor unit, having a resistance matching the length of the first and second pipes.

2. The air conditioner according to claim 1, wherein one end of the plurality of capillary tubes of the outdoor unit is connected to the outdoor heat exchanger, and the other end of the same is connected to a connecting valve to which the second pipe is to be connected.

3. The air conditioner according to claim 1, wherein a refrigeration system is formed by connecting the second pipe to one of the plurality of capillary tubes, the quantity of a refrigerant contained in the refrigeration system is determined on the basis of a combination of the greatest length of the first and second pipes and the resistance of the capillary tube having the lowest resistance, and reservoir tanks are connected in series to the capillary tubes except for the capillary tube having the lowest resistance, respectively.

4. The air conditioner according to claim 3, wherein the reservoir tanks having greater capacities are connected to the capillary tubes having higher resistances.

5. The air conditioner according to claim 3 or 4, wherein

the reservoir tanks contain a desiccant.

6. The air conditioner according to claim 2, wherein the connecting valves are mounted on a side wall of a casing of the outdoor unit.

7. The air conditioner according to claim 6, wherein the connecting valves are arranged at horizontal intervals.

8. The air conditioner according to claim 6 or 7, wherein the connecting valves are mounted on the side wall of the casing of the outdoor unit at different heights, respectively.

9. The air conditioner according to claim 6 or 7, wherein marks respectively indicating the lengths of pipes to serve as the second pipe and to be connected to the connecting valves are provided on the side wall of the casing of the outdoor unit on which the connecting valves are mounted, at positions near the connecting valves to which the pipes are to be connected, respectively.

Patent Office

Application No:	GB 9817686.0	**Examiner:**	Paul Gavin
Claims searched:	All	**Date of search:**	29 October 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): F4H(HGXP,HGXM,HGXR,HGXT3), F4V(VFYM,VFYN,VFYX)

Int Cl (Ed.6): F25D(19/02,23/10)

Other: Online WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2 298 707 A	(TOSHIBA)	
A	GB 2 217 826 A	(MATSUSHITA)	
A	GB 1 505 218	(MATSUSHITA)	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.